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BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Paper No. 12

Application Number: 09/672,375
Filing Date: September 28, 2000
Appellant(s): HUSSEIN, MAKAREM A.

Angelo J. Gaz
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed January 30, 2003.

(1) Real Party in Interest

A statement identifying the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

A statement identifying the related appeals and interferences which will directly affect or be directly affected by or have a bearing on the decision in the pending appeal is contained in the brief.

(3) Status of Claims

The statement of the status of the claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Invention

The summary of invention contained in the brief is correct.

(6) Issues

The appellant's statement of the issues in the brief is correct.

(7) Grouping of Claims

Appellant's brief includes a statement that claims 12 – 17 do not stand or fall together and provides reasons as set forth in 37 CFR 1.192(c)(7) and (c)(8).

(8) Claims Appealed

The copy of the appealed claims contained in the Appendix to the brief is correct.

(9) Prior Art of Record

6,323,131	Obeng et al.	11-2001

(10) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claims 12 – 17 are rejected under 35 U.S.C. 102(e) as being anticipated by US patent No. 6,323,131 to Obeng et al.

Regarding claims 12 and 16, Obeng et al. teaches an integrated circuit (Fig. 1(d)) comprising:

a substrate having a circuit device (22);

a dielectric material (10) over the circuit device with a via to the circuit device, wherein the via exposes a sidewall in the dielectric material and a surface of the circuit device;

a barrier material (18) lining the walls of the via;

a seed layer overlying the barrier material and lining the walls of the via (Col. 4, lines 21 – 24); and

a conductive material (20) directly contacting the exposed surface of the circuit device.

Regarding claim 13, Obeng et al. teaches an integrated circuit, wherein the circuit device is an interconnection line.

Regarding claim 14, Obeng et al. teaches an integrated circuit, wherein the conductive material is copper.

Regarding claims 15 and 17 Obeng et al. does not explicitly disclose an integrated circuit, wherein the barrier material can be etched selectively in the presence of the seed material. Obeng et al. teaches an integrated circuit, wherein the barrier material (self-assembling organic material) and seed material (copper) comprise different materials that would have inherently used different etch chemistries/rates, thus the barrier material could have been etched selectively in the presence of the seed material.

(11) Response to Arguments

Group I

The applicant argues that Obeng et al. does not anticipate the limitations set forth in the claims of Group I because Obeng et al. does not describe a conductive material directly contacting the surface of the circuit device. The Applicant bases this argument on the fact that Obeng et al. does not explicitly state that the barrier film (18), the copper seed layer and the self-assembling film (24) is removed from the first copper layer (20) of the device depicted in Fig. 1(d) of Obeng et al. The Applicant further asserts that the figures of Obeng et al. are vague and not consistent with the text.

The disclosure presented in a patented invention cannot be viewed in a vacuum, but within the purview of the skill of one having ordinary skill in the art. See 37 CFR 1.71 (a), printed below for the Applicant's convenience:

> *The specification must include a written description of the invention or discovery and of the manner and process of making and using the same, and is required to be in such full, clear, concise, and exact terms as to enable any person skilled in the art or science to which the invention or discovery appertains, or with which it is most nearly connected, to make and use the same (emphasis added).*

When the state of the art is considered, the written disclosure and drawings of Obeng et al. are in full agreement with each other and disclose the invention of the instant application. This point will be addressed in detail in the rebuttal to the Applicant's arguments below.

The Applicant cites Col. 4, lines 21 – 24 of Obeng et al., which discusses the steps of forming the lower portion of the interconnection structure shown in the incomplete device of Fig. 1(b), wherein a thick copper layer caps a copper seed layer. Obeng et al. further discloses in lines 25 – 29 of the same column, that a CMP (chemical-mechanical-polish) step is performed, stopping at the oxide layer (10), which also exposes the copper layer (22), as shown in Fig. 1(c). The Applicant also cites Col. 4, lines 33 – 35, where Obeng et al. discloses that "...The above steps may then be repeated as required to form a device having multilevel interconnections as in Fig. 1(d)", asserting that, since Obeng does not explicitly state that the lower copper layer is exposed to the upper copper layer, that it is not the intention of the invention to have the copper structures contact each other.

As shown in Fig. 1(d) in the left half of the figure, an interconnect structure is shown, wherein the lower copper structure (20/22) (circuit device, being an interconnection line) is in direct contact with the upper copper layer (20). The passivation layer (24) is shown in the drawing to be disposed over the exposed copper structure and oxide. The drawing further shows a possible seed layer, represented by an unlabeled dark line.

Obeng et al. does not explicitly state that a portion of the self-assembling organic passivation film (18) is removed, as shown in Fig. 1(d), which would enable the upper copper layer to directly contact the lower copper layer. Leaving the self-assembling organic film between the lower copper structure and upper copper structure would have been outside of the spirit and scope of the disclosed invention. The self-assembling organic film is disclosed as having an organic compound having the formula $X[(CH_2(Ch_2)n—O—C(O)CH_2C(O)CH_3]_2$, wherein X is S (sulfur), Si (silicon), or N (nitrogen) and n is from 2 to 18 (Col. 2, lines 65 and 66). The self-assembling organic film would have been an insulator having dielectric properties, as opposed to being another layer of conductive material. In leaving this dielectric material between the layers of copper, capacitance would have been introduced into the interconnect structure resulting in a significant RC time delay, the very thing that is undesirable in interconnect structures (See Col. 1, lines 12 – 14). Additionally, since the scope of the invention is to produce an interconnect structure and not a series of capacitors, one having skill in the art would have known to remove the dielectric material before depositing a conductor (20) on the first conductor (20/22) as shown in the final structure

(Fig. 1(d)). The self-assembling organic film can be easily removed by plasma/wet etch processing (Col. 2, lines 60 and 61).

An object of the invention is to prevent the migration of copper to the underlying substrate (Col. 1, lines 51 – 53). Since it is detrimental to the operation of the device to introduce capacitance into the interconnection structure (as discussed above) and there is no need to prevent copper from migrating to copper, it is clear to one of ordinary skill that Obeng et al. sufficiently discloses that the self-assembling organic layer is not disposed between the circuit device (lower copper structure (22/20)) and the upper copper structure.

With respect to Applicant's assertion that Obeng et al. does not explicitly disclose removing the barrier film between the two copper conductors, the barrier material also comprises the self-assembling organic film as discussed above. Since there is no need to protect copper layer (22/22) from copper migration, and the film would have introduced even more capacitance than the passivation film (the barrier film is thinner than the passivation film), one having ordinary skill in the art would not have misunderstood the disclosure to mean that a diffusion barrier film should be placed between the lower and upper portions of the copper interconnect structure.

On page 6 of the brief, the Applicant argues that "...Obeng only describes thick copper thick copper film 20 capping the seed layer and the barrier film", citing col. 4 at lines 21 – 24, where a description is given of the *partially fabricated device* of fig. 1(b), where the barrier film has been deposited over the substrate for the expressed purpose of preventing the migration of copper to the underlying substrate (Col. 2, lines 27 – 31).

The purpose of the copper seed layer is generally to make it possible to form a copper layer via electroplating, wherein the copper seed layer is biased during deposition to serve as a cathode. The applicant further asserts that one having ordinary skill would have necessarily and precisely repeated the steps described in lines 21 – 24 of column 4 to form a multi-layered interconnect structure. This would have required one having ordinary skill to provide a film for the prevention of the migration of copper atoms between two copper layers, which would have only introduced capacitance to the line. It would have further required one having skill in the to deposit a thin copper layer on the copper layer before depositing the second copper layer. As discussed above, the barrier film between copper layers is not needed and would have been detrimental to the operation of the interconnect structure. Additionally, the copper seed layer would have only been needed on the sidewalls comprising the organic material. There is no need for a copper seed layer in the bottom of the trench because a copper layer is already there. One having ordinary skill in the art would not misinterpret the specification of Obeng et al. to require a thin layer of copper (used for electroplating) be left on the a layer of copper before depositing a third layer of copper. However, assuming a copper seed layer were added to the copper circuit device, it would have resulted in a copper circuit device that was a little bit thicker than before since there would be nothing to delineate thin seed copper layer from the thicker underlying layer. Therefore, *if* it can be read from the specification that there is a teaching of leaving a copper seed layer on the copper circuit device (20/22), the second (20) and first copper

(20/22) structures would indeed be in direct contact with each other since copper on copper produces a copper layer that is a little bit thicker.

On the top of page 7 of the Appeal Brief, the Applicant argues that the dark line representing a seed layer in Figure 1(b) is inconsistent with the omission of layer 18 in figures 1(c) and 1(d) since Obeng et al. does not describe removing layer 18 from the bottom of the via. As stated above, the disclosure of Obeng et al. must be read with the understanding of one having ordinary skill. As an example, a disclosure of a capacitor, wherein the capacitor dielectric has some inventive feature would not necessarily require a description of forming an upper capacitor plate because one having ordinary skill understands that this is needed. Nor is it necessary to explicitly disclose to one having ordinary skill that a dielectric layer (self-assembling organic film) should not be disposed between layers of an interconnect line, since the line should function like a wire for optimal speed, not several capacitors connected in series.

In support of the assertion that the steps described in lines 21 – 24 of column 4 to produce the partially completed structure of figure 1(b) would be duplicated to produce the structure of figure 1(d), the applicant cites lines 33 – 36 of column 4, which states, *"The above steps may then be repeated as required to form a device having multilevel interconnections as shown in Fig.1(d)"* Although the steps of removing a portion of the passivation material and barrier are not explicitly described by Obeng et al., the specification should not be read in a vacuum, but with the level of understanding that one having skill in the art would possess. The feature of not having a passivation layer between the lower copper layer (20/22) and the upper copper layer (22) is

inherently disclosed for reasons cited above. Furthermore, since the purpose of the passivation layer is to protect the copper from air corrosion (Col. 2, lines 17 – 20) and avoid interaction with adjacent dielectrics (Col. 1, lines 33 – 35), there is no need for the layer between two copper layers.

The Applicant argues that removal of layer 18, the self-assembling organic film is not a "known technique", asserting that Obeng et al. teaches depositing barrier, seed and interconnect layers using "known techniques". Obeng et al. discloses that the self-assembling organic films and barrier membranes may be destroyed during plasma/wet etch processing (Col. 2, lines 51 – 61), which is nothing new in the art.

Group II and IV

The Applicant argues that Obeng et al. does not have an inherent teaching, wherein the barrier layer comprises an etch characteristic such that the barrier material can be selectively etched in the presence of the seed material (copper). Note that there is no requirement to actually selectively etch the barrier layer in the presence of copper, only that the barrier layer has such an etch characteristic. The Applicant cites Col. 3, line 64 in support of this argument, stating that Obeng teaches a barrier material comprising a refractory material and the seed material lines the barrier material. Obeng et al. does not teach or suggest using a refractory material for the barrier layer anywhere in the disclosure. Obeng only teaches a self-assembling organic film for the barrier material. Organic material, when using chemistries that are designed to attack the organic material, would be expected to have a faster etch rate than a metal and the organic barrier layer would inherently etch faster than a metal. The etch characteristic

of the Organic material, being similar to photo-resist would allow it to be etched selectively in the presence of the copper material used for the seed layer.

In response to the Applicant's request for a reference in accordance with MPEP 2144.03, the following references are provided showing that organic materials (the barrier) have an etch characteristic such that it can be etched in the presence of the seed material (copper):

US patent No. 3,784,440 to Grunwald et al. (Col. 2, lines 30 – 33)
US patent No. 6,362,089 to Molla et al. (Col. 2, lines 35 – 38)
US patent No. 5,290,608 to Grunwald et al. (Col. 4, lines 23 – 27)

Group III

The Applicant asserts that Obeng et al. does not teach a conductive material in a via having a seed layer and a barrier material formed so as to expose a circuit device at an end of the via. The Applicant seems to be in agreement that a barrier layer (18) and seed layer is formed in the via of the upper portion of the device depicted in Fig. 1(d). However, the Applicant argues that the seed layer and barrier material are not formed so as to expose the circuit device. The method by which the barrier material and seed layer are formed are only of concern in so far as how they relate to the final structure of the invention when claims are drawn to a product. In other words, in a product claim the determination of patentability is based on the product itself. Assuming that a copper seed layer is not removed from the lower portion of the trench, there is nothing in the final structure to distinguish the copper structure (22/20) from a copper seed layer deposited thereon, so it could be said that the copper seed layer on top of the

underlying copper layer (22/20) would be incorporated into that copper layer (22/20). However, there is no need for a copper seed layer on a copper layer since copper can easily be electroplated to copper. The question remaining is, would someone having skill in the art leave a layer of dielectric material between layers of a conductive interconnect line? Since it is detrimental to the operation of the device to introduce capacitance into the interconnection structure (as discussed above) and there is no need to prevent copper from migrating to copper, it is clear to one of ordinary skill that Obeng et al. sufficiently discloses that the self-assembling organic layer is not disposed between the circuit device (lower copper structure (22/20)) and the upper copper structure, in light of the state of the art.

Summary

The focus of the Applicant's arguments centers on the fact that Obeng et al. does not explicitly describe each and every detail of the invention, although they are clearly shown in the figures. It has been established that the specification only need include a description that is clear to one having skill in the art. It is helpful to consider the objectives of the invention taught by Obeng et al. while considering the background and state of the art. Obeng et al. discusses the need for fast interconnect technology and using metals with low resistivity, such as copper, to provide this need (Col. 1, lines 12 – 53). The problems associated with using copper, are prevention of copper migration *to the underlying substrate* (emphasis added) and prevention of corrosion on the copper surface. Accordingly, Obeng et al. sought to provide a barrier material that would resolve these issues. An interconnect structure having layers of organic barrier material

between conductors would have introduced an RC time delay, circumventing one of the industry wide goals of producing fast interconnect structures. Additionally, the suggestion of forming a copper migration prevention film between two layers of copper would not be plausible for one having skill in the art because there is no need to prevent copper from migrating to copper. Since Obeng et al. discloses that the self-assembling barrier material can be removed by simple plasma/wet etch processing, there is sufficient disclosure for one of ordinary skill to be capable of removing the organic dielectric material before depositing the upper portion of the interconnection structure, as shown in Fig. 1(d). Finally, it has been shown that organic materials have an etch characteristic such that it can be etched in the presence of the seed material (copper) since the etch characteristic is similar to that of photoresist.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

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March 27, 2003

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